

AN ELECTROMYOGRAPHIC INVESTIGATION
OF HYOID MUSCULATURE

by
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A DISSERTATION SUBMITTED TO THE GRADUATE COUNCIL, OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA
(Gainesville 1960)

ACKNOWLEDGEMENT

The author expresses his appreciation to Dr. Mohammed Saad for his encouragement and assistance during work in the initial stages of preparation of this dissertation. He is also grateful to Dr. Henry Weillner for his help and guidance in the final stages of work on this dissertation.

In addition, the author acknowledges the cooperation of the Department of Communication Disorders and the University of Florida Medical Center for making available their facilities.

Finally, the author is especially grateful to his wife, Beverly, and his children, David and Jeffrey, for their patience and encouragement during his months of study.

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CHAPTER I

REVIEW OF THE LITERATURE AND PURPOSE

Introduction

Detailed studies of the muscles of the body that both affect and affect a particular motor movement wait to be completed before a comprehensive theory of neuromuscular control can be developed. It is not only necessary to have had a movement to begin but also how it is accomplished. More importantly, an understanding of neural dynamic events functioning is necessary for comprehension of basic speech physiology as well as for abnormal function. Even with recent technical advances, many aspects of motor patterning remain unexplored.

Study of muscle function has been distinguished by use of a number of methods. Nash and Nash (1981) point out that there are at least five approaches to the study of muscles in order to determine their action:

1. Study of the positions under which a muscle acts by the use of a motion platform, holding the subject at equilibrium, directional path, leverage, and then the other action bearing upon the problem that can be discussed.
2. Isolating the partly dissected muscles of the subject not involving the remaining movements
3. Submission of individual muscles by electric current not involving the remaining movement

- 4- The study of subjects who have lost the use of certain muscles or structures: what loss of power and movement have resulted and whether any abnormal postures have been produced.
- 5- Study of the normal living body to find what muscles contract in order to perform certain exercises and what movements will contract muscles like willow.

Advantages to each of these methods are procedural advantages and disadvantages. When using the skeleton and cadaver, it is not possible to determine spontaneous action as movement usually involves groups of muscles and a given muscle may act with various others to accomplish different movements. However, it does not follow that these muscle actions will necessarily be the same in a live subject. With respect to electrical stimulation, of course, a known stimulus may be applied to a muscle and the resultant action may be explained, however, with this method, the motion to be studied must necessarily be those directly brought about, consequently, observation is limited to superficial motions. In the study of subjects who have lost the use of certain muscles, it is not possible to ascertain their contribution in a particular movement in an intact and functional system. That these methods only provide information concerning what a muscle may do, not what it will do. As Smith and Burke (1960) state:

We need to learn not only what motion a muscle is able to perform because of its position and appearance but also when, in an actual state, the nervous system calls upon it to do and when it permits it to do this thing. (1960)

The study of the normal living body is perhaps the most practical approach to the investigation of muscle function and should

furnish the most fundamental data. This may be done in two different ways. In the first, it is possible to see or actually feel the muscle movement but as the muscles studied may not be those that the clinician believes the skin surface, the limitations of electrical stimulation also apply to this approach. A second method of studying the normal living muscle is by the use of electromyography (EMG), a technique that gives measurable objective data. Deacon (1960) states that "Electromyography is a technique especially suited to the analysis of skilled movements in general, and of speech in particular." By using needle or surface electrodes, direct information can be obtained concerning muscles that are active under specific conditions. The use of surface electrodes necessarily must be limited to the study of superficial muscles, but needle electrodes may be used to measure that the deep within the body. Needle electrodes, therefore, would seem better suited for study of the speech musculature.

It is important that there are limitations to the study. Some of these are summarized by Trevis (1960), i.e., discomfort from insertion of needle electrodes, superimposition of electrical interference from lines, and variations in recording conditions. In addition, the equipment needed for EMG is expensive, quantification of results is difficult, and data reduction is extremely time consuming. However, it appears to be the best technique available for the study of muscle function.

Electromyography has proved to be a useful research tool since the pioneering work of Sherrin and Trevis (1950); for example,

Tomas, Saunders, and others (1944) reported data on changing nerve conduction. Their study was one of the direct investigations using EMG which was somewhat extensive and not purely clinical in nature. Since that time, other areas studied have included muscular fatigue, muscle mechanics, posture, and the function of locomotion and so on. In the field of speech, numerous studies have been conducted with utilizing EMG. Heston (1950), Brown, Lohfage, and Whitcombe (1951), Smith (1952), and Allen (1954) have investigated the function of supralaryngeal musculature, Boland (1957) and Cooper (1957) have studied vocal cord activity and Davis (1954) and Williams (1955) have studied muscle firing during speaking blocks. However, Farkas-Geserman (1957) has completed a study of both normal and abnormal laryngeal muscular control of the larynx and Sandberg and Boland (1959) have tried to define electromyographically the functioning of tongue muscles during phonation. As yet, one relatively unexplored area is that of mandibular movement, especially with respect to those muscles that affect jaw depression. Since jaw depression is necessary in oral speech production, an understanding of the mechanism necessary for this act is basic.

The literature does not contain any studies that have dealt exclusively with the motion of jaw depression. In fact, there is some theoretical disagreement about which muscles actually do accomplish such movement. Thus the purpose of this research is to examine (in normal subjects) the action of superior and inferior orbicular muscles in certain defined acts of jaw depression. Since the mandible is essentially a single structure with its movement rotating

from the temporomandibular joint, a discussion of the pertinent research related to temporomandibular and submandibular function will be found in the following sections.

Role of Jaw-Closing Muscles

Jaw closing muscles, e.g., the masseter, lateral pterygoid and temporalis, have received much investigation, especially by dental researchers. Neffington and Jensen (1951) studying primarily the temporalis and masseter muscles by means of surface electrodes, found that in human subjects, activity was centered mainly in the masseter and to a lesser extent in the temporalis; however, in other subjects, the activity was more or less equal in both of these muscles. Observation of the mandible seemed to show a greater development of the masseter muscle, while maximum apical resistance showed activity over the posterior fibers of the temporalis. Rogers (1944 and 1950), in an extensive analysis of the mandible involved in temporomandibular movements using both surface and needle electrodes, found a regulated interaction of several muscles. His conclusions were that elevation of the mandible was brought about by the coordinated contraction of the lateral pterygoid, masseter, and temporalis muscles. Lateral movements were achieved by the ipsilateral contraction of the temporal muscle and contralateral contractions of the external and internal pterygoid. Vertical protrusion of the mandible and simultaneous contractions of both the pterygoid and masseter was effected by the contraction of the middle and posterior fibers of the temporalis. In all of

these membranes, he found more action in the supradental group as defined by a certain electrode placed over the digastric muscle. He judged that the supradental plays an important role in stabilizing the head bone to achieve some of the more delicately adjusted jaw related action. As in nearly all the studies these muscles were qualitative and not quantitative. Additionally, Perry and Harris (1954), using surface electrodes, found the temporal muscle to be dominant in the initiation of masticular movements, however, they did not test for supradental action. Harris and Mayne (1955), Zarbala (1954), and Rogers (1957) studying related cases found these relationships to be somewhat related due to pathology.

Role of Jaw Stabilizing Muscles

A sampling of muscular activity within Gray (1955), Gray (1954), and Harris (1957) among others, includes the digastric, mylohyoid, splenhyoid, and geniohyoid as supradental muscles and the tensorhyoid, sternohyoid, thyrohyoid, and mylohyoid as subhyoid muscles. These muscles in addition to the external pterygoid are considered to play some part in jaw depression although there is disagreement as to which muscles and in the primary jaw depressors. Hunter (1954) in a clinical and roentgenographic study of temporomandibular articulation observed the external pterygoid exhibiting 140% movement of the jaw, and therefore assumed that the supradental muscles acted as jaw depressors. Fox, Rigg, and Truitt (1958) and Mayne (1955) also contribute jaw opening to the subhyoid muscles. Apparently, the subhyoid

group was to have one hyoid bone (1) in three positions or more in tandem depending upon the extent of the suprathyoid mandibular. The Tiger and Lewis (1940) further state, in a detailed description of the production of vocal and associated phenomena, that active participation of these vocal process is necessary when mandibular depression is needed for the production of a sound. This action of the suprathyoid mandibular therefore is assumed also for all jaw depression. Austen (1934) (Wray 1937, Boyd 1938) also suggest the view that jaw opening is brought about by lateral movement from the external pterygoids, selective relaxation of the jaw elevators, approximation of the hyoid bone by the infrahyoid mandibulars, and contraction of the suprathyoid muscles.

Myers (1940) found that in mandibular depression the two external pterygoid muscles act synchronously "from above" before the anterior belly of the digastricus. In vocal sounds contributed by the pterygoid and surface musculature over the digastricus. However, he did not specify the extent of jaw depression or the differentiated in time. The total premastication time of the digastricus was 1.16 seconds, 1 s., the time total time for the act was 2.17 seconds and the time time of the digastricus was 1.41 seconds. However, in isometric mandibular depression the time total time of contraction was 2.38 seconds and for the digastricus 1.38 seconds. However, during mandibular depression, when premastication of equal amplitude to those of the digastricus were given to the suprathyoid. Further, when using surface electrodes on the anterior belly of the digastricus, Myers (1938) found electromyographic recordings similar

in those of jaw opening when the tongue was protruded, when a tongue tip movement was forced, or when the subject swallowed. He stated that the digastrics demonstrated activity during all mandibular movements. He strongly requested importance of maintenance of position of the hyoid bone and stabilization of the mandible of the mandible in order to have movement in any action of the lower jaw. Thus he felt that it was reasonable to believe ".....that the role of digastrics during most mandibular movements is to stabilize and govern the action, not to initiate it, to regulate not initiate."

Contrary to the view, Lord (1900) and Lord and Bennett (1907) concluded that the jaw is depressed in ordinary mouth opening by the unassisted action of the two external pterygoid muscles. They stated further that in forced depression, the digastric muscles assisted by preventing excessive tension on the stylohyoid ligaments. Their conclusions were drawn from a working model of the skull and mandible which followed, as nearly as possible, the moving and ligamentous attachments determined from a great many dissections. The difficulty in these procedures have already been discussed. Consistent with Lord, Lord (1900), using a different approach stated:

.... the external pterygoid muscle is the muscle of mastication that raises the lower teeth to contact, opening of the mouth. It is able to do this by the complete relaxation of the other muscles that are associated with the functioning of the opening of the mouth.

He did, however, add that the infrahyoid muscles may assist in a non-depressing external pterygoid by producing a forced opening of the mouth. He based his statements on the evaluation of

the clinical notes: In one, a bilateral mandibular ankylosis was done in which the upper third of the posterior portion of the ascending ramus was removed, leaving the coronoid process intact. With this patient, he found definite visual and palpable evidence of marked contraction of the inframandibular muscles on opening of the mouth, he did not observe partial motion in normal individuals (except for forced opening). In his second case, a cold-induced palsy used to the patient destroyed the entire front of the mouth as well as the anterior portion of the mandible, destroying thereby all of the attachments of the inframandibular muscles. The patient was able to depress that portion of the right body of the mandible which remained intact in spite of the fact that none of the inframandibular muscles were functioning. The external pterygoid was the only muscle remaining attached to allow mouth opening.

In an electromyographic study of the temporalis and masseter muscles, Bachopgall and others (1942) using surface electrodes found that, during ordinary unforced mouth opening, the greater part of the movement resulted in an activity beyond the basic resting potential in the superior and lateral pterygoid muscles. Normal mouth opening and sustained opening, however, were accompanied by "considerable" activity. No muscles are able of electrode placement.

Summary

From the material presented above, it is apparent that there are conflicting opinions regarding the actual muscle functioning in the superior and lateral pterygoid groups during mandibular movement. Some

authors (Jard 1943, Lord and Bennett 1953, Hunt 1964) feel that, for suggested jaw opening at least, the external pterygoids and the muscles primarily associated with their movement. They believe that while supra- and infratemporal muscles may play some part in jaw depression, it is not even necessary that they be present to complete the act. They do not suggest, however, alternative functions of the hyoid muscles. However, they do conclude that these muscles may play a role in maximal and restricted jaw depression. Other authors (Jagers 1941 and 1950; Van Riper and Irwin 1948, Kaplan 1960), while not rejecting the external pterygoid muscles as jaw depressors, maintain that both supra- and infratemporal muscles form an integral part of the mechanism of jaw depression. They contend that these muscles actively assist in lowering of the mandible, and also give movement to any action of the jaw. However, it should be stated that much of the data on these muscles are theoretical in nature. However, when more definitive techniques, such as EMG, have been used, only the digastric muscle has been studied in these conclusions on total hyoid musculature. Van Riper and Irwin (1950) imply that most such investigations have been incomplete when they state:

It is almost impossible to be sure of the behavior of a single muscle acting synergistically (in coordinated action) with a group of other muscles in the absence of appropriate knowledge from the whole. All that the experiment can do is describe the possibilities and probabilities of muscle action.

Kennel (1960) supports this contention when he argues:

"....the muscles of mastication, the infratemporal muscles, and the

suprapatoid muscles of the floor of the mouth are virtually virgin territories for electromyographic exploration....." However, most studies utilizing EMG techniques have only tentatively examined the hybrid muscle groups and then overlap only with random elements (Payson 1949 and 1956, Huchingsall and Jensen 1960).

Since the function of the supra- and labiodental muscle groups in jaw depression is not clear, electromyography using needle electrodes appears to be ideally suited investigation of their activity related to jaw opening.

PURPOSE

The general purpose of this research was to determine, through electromyographic recordings, the presence or absence of specific muscle action in selected areas of jaw depression and the patterns of such activity of protest. The study investigated activity of the sublingual, geniohyoid, anterior belly of the digastric, and the sternohyoid muscles in unopposed one-quarter, one-half, maximal, and resisted jaw opening. The external pterygoid muscle was not investigated because it is relatively immovable with respect to the techniques available.

Specific questions to be answered by this research were:

1. Do these myoelectric potentials observed in these muscles during jaw depression?
2. Does increased muscle action potential occur as the degree of jaw opening is increased?
3. Is there differential action of any of these muscles during jaw depression?

CHAPTER II

PROCEDURE

In order to obtain muscle action potentials (MAP) electrophysiologically of the supra- and infrahyoid muscles, and to describe their function to various degrees of jaw opening, the following procedures were carried out:

Subjects

Five normal adult males, with a mean age of 31.4 years, served as subjects. All were volunteers and had no other dental and neck issues. This was necessary to assure that electrode placement would be easier and more consistent. None of the subjects had dental occlusal problems, exhibited any pathology of speech, or had a history of trauma or operations to the head or neck region.

Instrumentation

The data collected consisted of muscle action potentials (MAP) from both the right and left sides of the geniohyoid, suprahyoid, anterior belly of the digastric, and the mylohyoid muscles. The MAP were recorded physically as a direct electroencephalograph (EEG) model lead. The low Thorne frequency was set at 1 and the gain at 75. An internal calibration signal of 50 microvolts equal to 1 millimeter of amplitude was used to check voltage of all recordings.

A expolometer, a hand holding device, as described and used by Ryznar, Ryznar, and Smith (1960) was utilized in this subject position, in use is seen in Figure 1. This device, consisting of a leather hand postholder with six steel tension rods, kept each subject's hand in a stationary vertical and horizontal plane. The expolometer was attached to a metal frame, 42 x 17 inches, built especially for this purpose. It was constructed of 1/2 inch angle iron, cross-braced and had large washers fast for stability. The expolometer could be raised or lowered the appropriate height of the subject who was seated in a standard straight-backed office chair. The expolometer, stand, and chair were grounded to reduce electrical interference.

The apparatus for applying resistance to jaw opening (see Figure 2) was built of wood and had a base of 18 1/2 x 17 1/2 inches. A frame was 42 inches in length, made from 1/2 x 1 1/2 inch stock, was supported by two uprights 16 inches tall. The arm had a 1/2 x 1 inch padded surface for the subject's chin rest. To make the lower arm freely movable with as little resistance as possible, a metal tube was inserted through the middle of the arm and a metal pin was inserted through the tube in the supporting upright. The resulting clearance was 1/4 inch from the end of the arm which was held in a horizontal position by a wooden bar placed between the uprights 12 inches tall. A one pound metal weight was hung 12 inches from the subject's end of the arm. This distance was determined by placing a one pound weight on the chin rest and balancing it with an opposing one pound weight at the

Figure 1. distances for resolved for spacing with subject substituted by experimental;



II hooker diameter which allowed for the weight of the lower arm.

All the EEG recordings were obtained in the EEG Sleep Laboratory suite at the University of Florida Teaching Hospital. The recording apparatus was located in a control room adjoining the sound treated room in which the subjects were placed for the experimental procedures. The test room was shielded with copper screening and had a single common ground to eliminate interference with the EEG recording equipment. An intercommunication system and observation window connected test and control rooms.

Electrode Placement

Electrodes used in this research were of the single cannula needle type, Type Model 6110. The EEG electrode has a tapered stainless steel tube 18 gauge on the handle and 18 gauge on the tip. The lower electrode is a nichel chromium alloy wire 60K inches in diameter contained within the bore of the needle and is insulated from the needle shaft by a synthetic epoxy resin. The epoxy electrode has 18 inch flexible leads and insulated phono clips.

All needle electrode insertions were done by physicians of the Biophysiology Division of the Department of Surgery of the University of Florida Teaching Hospital. The skin area of the neck and chest was shaved with a razor and the electrodes were inserted bilaterally into the thyrothyroid, parathyroid, anterior belly of the digastric and the sternocleidomastoid muscles, by placing the needle shaft into the hollow of the muscle in the following manner:

1. Genioglossal: from a superior to inferior position with the shaft approximately parallel to the muscle fibers.
2. Mylohyoid: from an inferior lateral to a superior lateral position with the shaft approximately in an oblique relationship to the muscle fibers.
3. Anterior belly of the digastric: from an inferior lateral to a superior lateral position with the shaft approximately in an oblique relationship to the muscle fibers.
4. Stapedius: from an inferior to superior position with the shaft approximately parallel to the muscle fibers.

All eight needle electrodes were held in place by an aluminum surgical tape holder (NM). Finally, a clip-on electrode was placed on the subject's ear to provide ground.

Experimental Conditions

The experimental conditions, for which EMG recordings were made, included stopped jaw opening, one-half, stopped, and depressed maximal jaw opening. These trials were obtained for each condition; for maximal jaw opening, subjects were instructed to open their mouth as far as possible; for one-half and one-quarter jaw opening, they were instructed to open respectively, one-half and one-quarter this amount. It has been previously determined that these subjectively evaluated approximations showed little variation from positions indicated when the investigator measured the extent of maximal jaw opening and determined one-quarter and one-half jaw openings as a proportion of this value. Jaw depression for the related movement was the same as that for maximal stopped jaw opening. It was necessary that subjective evaluations

of one-quarter and stretched jaw springs to used on the subject was in the last run by himself except for the stretched jaw spring; consequently, it was not possible to have the conditions on several measurements. Thus, experimental conditions were not rigidly controlled but were rather approximations of jaw springs relative to maximal jaw depression. However, it was not possible to control the exact amount of jaw spring by artificial means or any type of an arrangement to stop the jaw at a particular point which have varied from resistance and the EMG electrical would not have been a true indication of the muscle function under unsupported opening. Each subject was allowed practice trials with and without electrodes until he could perform the experimental tasks to the satisfaction of the investigator.

Subjects

The subjects were first informed that the purpose of the procedure was to obtain information on the response of muscles during jaw opening. A brief description of the insertion of the electrodes and the EMG recording was given to them, as much as possible, and four subjects might have concerning the insertion of needle electrodes. They were told that there might be a little pain associated with the insertion but it would be mild.

The skin of the neck and chin area was cleaned with alcohol and, with the subject in a supine position, the electrodes were inserted and taped in place. A five to ten minute rest period was then given to be certain that there were no EMG artifacts from this procedure. Finally, the eleven ground electrodes was then attached

to the subject's ear hole.

Subjects were tested in the test room and the electrodes were coupled to the EEG. The subject's head was positioned to the electrode; and the investigator left the room. The EEG was amplified and the record was observed for artifacts, lapses in the statement were not to provide EEG recordings to eight separate channels. The subject was then instructed to say his name so that a check could be made to insure that all channels were operating properly. After a running potential was obtained, the experimental procedures were begun.

It was determined that maximal jaw opening influenced the EEG recordings obtained as heavy degrees of jaw depression when normally long rest periods were allowed using the various conditions. It was therefore decided that all experimental conditions would be carried out in the following order: supine, supine, one-half, maximal, and maximal jaw opening. It was recognized that this procedure might create an order effect but each was judged to minimize loss of a problem than having the EEG potentials affected by previous conditions. The entire experimental procedure lasted one and one-half to two hours, as a fixed period had to be maintained it was somewhat tiring. A shorter time was not possible as it would have required resumption of the electrodes and the physiological stimuli would have been started.

Before performing each task, the subject was instructed to remain silently so that when the investigator's voice stopped and there to begin that specific condition. Each run was terminated

by a hand signal from the investigator. Amplifications of each ear-drum lasted approximately ten seconds but trial duration could not be rigorously controlled. After the three conditions of unopened jaw opening, an assistant raised the lower jaw and positioned the apparatus for the restricted jaw opening condition. This individual remained in the room until the three trials of this condition were completed. At the end of the experiment the subject was again calibrated in order to insure that the equipment had functioned properly during the experiment.

Analysis of Data

The raw data, ECG tracings, were considered in two ways, the amplitude and frequency. Amplitude measurements were made for all traces. These measures were specified as the distance from the negative to the positive peak within a window one millimeter in length. Since the paper speed of the equipment was a constant 50 millimeters per second, a millimeter equalled 50 1/3 milliseconds. Frequency measurements were obtained by a visual analysis of the height of the potential to each one millimeter segment. These one millimeter segments were averaged to correspond to the 500 millimeter travel paper markings. Measurements were taken from one second preceding the experimental condition studied through one second following cessation of that condition. The amplitude measurements which were made for every minute, for every trial and over all conditions resulted in approximately 100,000 separate measurements.

These numerous artifacts made amplitude measurements impossible to obtain. The missing data were unduplicated by calculating the

sets of the amplitude on each side of the missing data points). If only one value was missing, adjacent points were averaged; but if two points were missing, extrapolation was based on two points on either side of the loss. It is estimated that less than one-quarter of one percent of the measurements had to be obtained by this method.

The EMG tracings (see Figure 1) were measured using modified and linear tracing graph paper number 44-1114 which is marked 20 x 18 on the centimeter. With the EMG tracings illuminated from below by an x-ray film box, the graph paper was overlapped and accurate measurements of both the time and amplitude could be made. Analyses of variance were computed among the mean amplitude for conditions, muscles, subjects, and replications.

Total period measurements were made. Muscle firing time was defined as the time from the first change in amplitude from the resting state of a muscle to the return to the resting state. Total firing time was calculated as the elapsed time from the initial onset of the first muscle to fire to the cessation point of the last muscle to stop firing for any trial. Because the period of each trial was not restricted, a ratio of muscle firing time to total firing time was made in order to obtain a percentage that was comparable for all subjects. Analyses of variance were computed among these ratios for conditions, muscles, subjects, and replications.

Measurements of onset of muscle firing were made beginning in the first muscle that fired in any trial. The first muscle

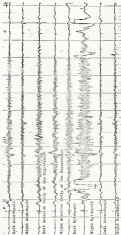


Figure 2 Sample of neural action potential of marbled sea squirts.

muscle activity was arbitrarily assigned a zero and elsewhere than measurements were taken from that point as the mean of EMG for each other muscle.

A fourth measurement was made. This was correction of muscle timing and was calculated relative to the first muscle to stop flexing during any given trial. This muscle was arbitrarily assigned a zero and elsewhere than measurements were then taken from that point as the correction of EMG for all other muscles. These measurements were made for every muscle during every trial for all conditions. It was not possible to treat these data statistically, therefore descriptive techniques only were used to evaluate onset and cessation time.

Three individuals, in addition to the investigator, distributed the data. Independent measures of degree and lagged observer reliability resulted in a P value of .0010 which would tend to indicate a minimum of measurement error among observers. Inter-observer reliability measures yielded Pearson r's of .96, .96, .97, .98 again demonstrating satisfactory measurement agreement among observers.

CHAPTER III

METHOD

This study is concerned with the muscle action potentials (MAP) of four vibratory muscles: the paraspinal, anterior belly of the digastric, trapezius, and sternocleidomastoid. Data were obtained from five normal male subjects under four conditions of jaw opening: unsupported non-quarter, non-half, neutral, and one period extended jaw opening. The data were analyzed for amplitude of MAP, percentage of total possible firing time, relative mass of muscle firing, and relative duration of muscle firing. This chapter presents the methods obtained by these measurement procedures:

Amplitude

Amplitude measures of muscle action potentials were obtained using a signal scale. Since the measurements were not standardized to voltage, all mass scores reported for amplitude will be in millivolt relative to 1 millivolt equaling 30 standard. It should be noted that subjects five did not complete the extended jaw opening condition. Therefore, the data for amplitude will be reported in two ways, i.e., four subjects, all conditions and all subjects, three conditions.

The fundamental purpose of this investigation was to determine the presence or absence of muscle action in jaw depression.

for the four muscles specified. This question can be answered in the affirmative. Action potentials for all experimental conditions show that the gastrocnemius, extensor hallucis digastricus, mylohyoid, and sternohyoid are active in jaw depression. Information concerning the nature of each muscle action will follow. Information relating to the experimental conditions will be presented first, followed by information on specific muscles.

Since all subjects performed each condition three times, the effect of replication on the experimental conditions was of interest. A slight decreasing trend was noted in EMG scores for replication. Specifically, the mean of the three replications for four subjects and four conditions were 1.26, 1.75, and 4.13; the mean for five subjects and three conditions were 2.04, 2.56, and 3.08. These observed means were interpreted to indicate that the best estimate of muscle action potentials would be an average of the three replications of each condition. The following results will be based on this assumption in this manner.

The muscle action potentials were recorded from both the right and left sides. Analyses of variance were computed in order to test the possibility that there was a side effect. The F values of 5.13 for four subjects, four conditions and 4.08 for five subjects, three conditions did not approach significance at the .05 level. Therefore, the data from the right and left sides of each muscle were pooled for subsequent analysis.

The headings for the tables and graphs displayed in this chapter will be abbreviated to the following format: "muscle +

gnathoid (GN), anterior belly of the digastricus (AD), mylohyoid (MH), sternohyoid (SH), conditions - one-quarter jaw opening (QJO), overhalf jaw opening (OJO), maximal jaw opening (MJO), resisted jaw opening (RJO).

Tables 1 and 2 present the means of the measures of the relative muscle action potential (RAP) for conditions and muscles. It should be remembered that as in this case, tables and graphs will be presented for four subjects, all conditions and all muscles, three conditions. They are repeated so that the rows present the myoelectric means for the gnathoid, anterior belly of digastricus, mylohyoid, and sternohyoid for jaw opening conditions and the columns present the average RAP by degree of jaw depression. By considering the group mean, it may be seen that as the degree of jaw depression increases there is a corresponding increase of RAP. This relationship constitutes one of the major findings of the study.

Tables 3 and 4 present the results of the analysis of variance testing the significance of the results observed in Tables 1 and 2, i.e., a systematic increase of RAP is seen as the degree of jaw depression becomes greater. It may be seen in these tables that the F associated with experimental conditions is significant beyond the .05 level. None of the other means were significant.

The significant F 's for conditions allow for testing of the differences among the associated means. The smallest difference needed for significance may be seen by referring again to

Table 1. Means of music action potential of conditions by music for four subjects.

Condition	Q20	Q50	Q80	Q90	Mean
Q1	1.44	1.48	1.74	4.80	3.73
Q2	2.82	2.88	4.27	5.82	4.80
Q3	2.77	2.87	4.20	5.72	3.86
Q4	1.40	1.78	1.78	4.84	3.05
Mean ^a	2.11	2.32	3.79	5.81	

The critical difference for post-hoc differences among the means (relative to condition) is 1.39.

Table 2. Means of music action potential of conditions by music for four subjects.

Condition	Q20	Q50	Q80	Mean
Q1	1.08	1.87	4.37	3.01
Q2	2.45	1.77	4.45	3.08
Q3	2.77	2.84	3.78	3.03
Q4	1.08	1.86	4.87	3.07
Mean ^a	2.37	2.34	4.39	

The critical difference for post-hoc differences among the means (relative to condition) is 0.77.

Table 3. Summary table of analysis of variance of measures of relative magnitude of man's action potential for four subjects, four conditions.

Source	df	ss	F	F .05
Condition (C)	3	449.58	4.51	3.48
Subject (S)	3	16.18	0.23	3.07
Subject x Condition (CS)	9	19.89		
SS	21	48.65		
CS	12	4.29	0.43	1.82
SSS	27	9.31		
Total	294	9.89		
Total	281			

Table 4. Summary table of analysis of variance of measures of relative magnitude of man's action potential for four subjects, four conditions.

Source	df	ss	F	F .05
Condition (C)	3	895.47	23.08	4.41
Subject (S)	3	5.94	0.17	3.34
Subject x Condition (CS)	9	83.24		
SS	12	34.45		
CS	18	84.75	0.47	3.34
SS	14	6.19		
SSS	24	9.00		
Total	240	9.44		
Total	237			

Table 1, it is 1.15. The difference between non-quarter and non-half, and between maximal and maximal jaw depression are not significant although the difference between non-quarter and non-half does approach significance. The difference between either the non-quarter or non-half and either the maximal or maximal jaw depression are all well above 1.15 needed for significance. When the five subject, three condition grouping is considered, all differences are significant.

A graphic display of the trends for conditions discussed above may be seen in Figures 3 and 4. The ordinate is scaled in units of relative amplitude and on the abscissa the points for the four maximal are indicated. The configuration of the graphs shows the relationship of each experimental condition to one another. It can be noted that not only is there nearly linear parallel for all conditions, but also in non-quarter, non-half, and maximal jaw opening there is an orderly progression of increases of muscle action potential. This relationship, however, does not continue for maximal and maximal jaw depression. In summary, it is apparent from the graphs of Figures 3 and 4, as well as the data contained in the Tables, that muscle action potential (MAP) does vary in all the investigated degrees of jaw opening and that there is a significant increase of MAP as jaw depression is increased.

It has been stated previously that no trend among muscles could be observed. It must be recalled any possible differential among them for differing amounts of jaw depression, the graphs

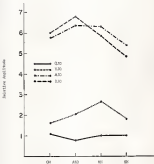


Figure 3. Motor action potential of conditions by muscles for four subjects.

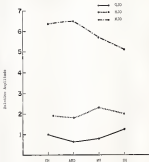


Figure 4. Mean relative amplitude of condition by number for flat subjects.

of Figures 3 and 4 were constructed. Relative amplitude is displayed on the ordinate and points along the abscissa denote the degree of jaw opening. The average amplitude of EMG for each muscle reporting each experimental condition is shown. It can be seen in Figure 3 that the mean amplitude for the four muscles are quite similar in one-quarter jaw depression, but the variances become greater as the degree of jaw depression is increased. The slope of the lines from one-quarter to maximal jaw depression is steep, indicating an accelerated increase of EMG among these conditions, while the relative leveling between maximal and maximal jaw depression indicates somewhat similar muscle firing patterns. No large differences are observed among the means of any one condition except for maximal jaw opening, but these differences are more apparent than real. Figure 4 (representing the five subjects, three condition amplitude) has essentially the same configuration as Figure 3, indicating similar relationships for data estimated in this manner. Re-examination of Tables 3 and 4 indicates that the F values obtained in each difference among the means for the muscles are extremely small (F_{12} and F_{14}). This confirms the observation that no significant differences exist among the means. Observation of the means for muscles from Tables 1 and 2 show the small differences among them. From the data presented it must be concluded that the geniohyoid, anterior belly of digastric, mylohyoid, and sternohyoid do not function differentially

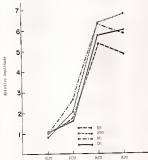


Figure 5. Relative amplitude of wave action potential of neurons by stimulation for four subjects.

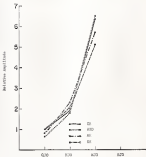


Figure 5. Relative amplitude of muscle action potentials of muscles by condition for five subjects.

for differential degrees of jaw depression.

Variability in the amount of the voltage potential among the muscles was expected because of differing subject size and the conditions under which muscle tension was sampled. Table 3 presents means of EMG amplitude for all subjects in all of the experimental conditions. It can be noted that there is substantial subject variation. However, inspection of the EMG readings showed that during non-jawed jaw depression, four of the five subjects did not register an action potential from at least one side of the muscle. For example, subject five showed no muscle action potential for both the superior belly of the digastric, and the mylohyoid muscles. This relatively similar to another case EMG amplitude for non-jawed jaw opening of subjects two, four, and five respectively. It is to be noted that subject two had unusually smaller amplitude measures for all conditions than did the other subjects. This individual had served as a subject in other investigations of this type and may have been more relaxed during the procedure. In any event, because of differences in subject anatomy (i.e., size), electrode placement, etc., variability among the subjects was observed. However, it was not felt to detract from the overall results of greater EMG being associated with increases in jaw depression, or the lack of any differential action among the muscles.

Discussion

In order to obtain a measure relative to percentage of

Table 3. Means of muscle action potential of participants by five subjects.

Subjects	Q30	Q70	Q90	Q95
1	1.15	3.91	6.06	6.86
2	0.68	1.16	3.67	3.77
3	1.08	3.43	9.15	5.83
4	0.86	3.15	3.41	8.39
5	0.65	1.04	3.34	na
Mean	0.88	2.49	3.91	5.86

firing time, two compared measurements were made and a ratio calculated. The measure was muscle firing time, the second was total firing time and was developed by extending the period from the first muscle to fire until the last muscle ceased firing. A ratio of muscle firing time to the total firing time gave deviation in percentage of firing time for that condition. The following results are based on this measure. For purposes of discussion, this ratio will be designated as total possible firing time.

The analysis of variance was carried out in the same manner as was that for amplitude. The overall mean of total firing time for repetitions were very similar 11.61, 11.60, and 11.41 for the four subject, four condition category and 11.47, 11.51, and 11.34 for the five subject, three condition category. Accordingly, 11 seemed feasible to average the data for repetitions. In the presentation of the following results, data will be considered in respect to results obtained for condition, followed by results obtained for subject.

As with amplitude, an use of post-hoc testwork to determine if the right and left sides of the four subject studied showed any differences in duration of firing. Accordingly, analysis of variance were computed to evaluate this design. The F ratio for the four subject, four condition category was not significant ($P=1.04$ at 1 and 10; $F_{.05}=3.84$) nor was that for the five subject three condition category ($P=0.00027$). The mean of percentage of total possible firing time obtained by grouping all muscles and all conditions for the left side was 81.79 and

and for the right side 98.34. Therefore, it was judged that the right and left sides of each muscle could be treated validly as a single muscle.

Tables 4 and 5 show evaluation of the data obtained during time. They are organized so that the rows present the names of the muscles, and the columns the same conditions. Examination of Table 4 reveals a difference of almost 40 percentage points between one-quarter and one-half jaw depression; 42 and 46 percentage points between one-quarter, neutral, and relaxed respectively; apparently, duration of firing increases with jaw depression.

Tables 6 and 7 present the results of analysis of variance to determine the statistical significance of muscle duration times. Both of the F's obtained for conditions (13-15 and 16-18) are statistically significant beyond the .05 level of confidence. The statistical differences noted in evaluate the means for conditions (regarding Tables 4 and 5 are 14.15 and 17.04 respectively). In each instance the only significant difference is between the value for greater jaw opening and the other means. Nevertheless, it is apparent that as degree of jaw depression increases the percentage of total possible firing time also increases. Further, evaluation of these relationships may be made by reference to Figures 7 and 8. The ordinate of the graphs show the percentages of total possible firing time and the abscissa indicate points corresponding to the four muscles. It is seen that there is an increase in the percentage of total possible firing time related to conditions.

Table 6. Means of percentage of total possible flying time of conditions by session for four subjects.

Session	QJO	QSO	QCS	QJO	Mean
Q1	83.71	94.43	94.36	94.38	93.23
Q2	43.85	91.41	75.14	97.85	80.81
Q3	37.84	88.39	94.43	94.57	78.81
Q4	49.44	76.79	95.67	93.49	78.84
Mean ^a	53.82	89.21	91.54	94.38	

^aThe critical difference for evaluating differences among these means (relative to conditions) is 18.31.

Table 7. Means of percentage of total possible flying time of conditions by session for four subjects.

Session	QJO	QSO	QCS	Mean
Q1	84.67	88.84	98.91	92.81
Q2	77.64	89.71	94.94	74.69
Q3	38.33	83.24	94.88	67.30
Q4	86.66	88.99	94.31	71.32
Mean ^a	58.12	89.21	94.76	

^aThe critical difference for evaluating differences among these means (relative to conditions) is 17.38.

Table 4. Summary table of analysis of variance of measures of percentage of total possible firing time for four subjects, four conditions.

Source		df	ss	F	F - 05
Condition	CC	3	40334.76	18.81	3.84
Residual	CC	7	818.85	8.38	3.87
Subjects	CC	3	2128.88		
CC		21	315.87	8.44	1.33
CC		9	6886.78		
CC		21	8347.91		
CC		87	2547.88		
Within		254	118.76		
Total		339			

Table 5. Summary table of analysis of variance of measures of percentage of total possible firing time for five subjects, three conditions.

Source		df	ss	F	F - 05
Condition	CC	2	12714.08	18.48	4.48
Residual	CC	7	1181.00	8.38	3.48
Subjects	CC	4	8287.80		
CC		14	773.84	8.73	1.74
CC		9	6750.82		
CC		28	8871.43		
CC		28	1074.89		
Within		244	281.11		
Total		308			

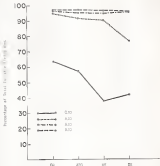


Figure 2. Percentage of total genetic mixing times of constituents by reaction for four vehicles.

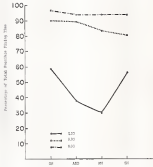


Figure 11. Percentage of total possible rising time of conditions by number for three subjects.

However, this effect is more marked between the managers and the other jaw opening individuals and is little different between maximal and relaxed conditions. The configurations on both graphs for relaxed and/or non-relaxed jaw opening show a more rounded dip in Figure 4.

The F statistic computed for differences of percentage of total possible firing time, as shown in Tables 4 and 5, are not statistically significant at the .05 level. (They are 4.44 and 4.48 respectively) These relationships also may be seen graphically in Figures 9 and 10. The individual data percentage of total possible firing time and the abscissa show points corresponding to the four experimental conditions, each line of the graph represents a different muscle under consideration. It is clearly seen that the configurations generated on both figures are quite similar for all conditions. There is considerably more variability among the muscles in the non-relaxed jaw depression than the other experimental conditions, but this is not statistically significant. The sharply rising slope of the lines indicates an increase in EMG for every muscle as jaw depression increases, but the proximity among the curves indicates that they do not act differentially to effect jaw depression. In any case, there appears to be no differential muscle action among the geniohyoid, anterior belly of the digastric, mylohyoid, and sternohyoid muscles relative to the percentage of total possible firing time for the four experimental conditions.

Table 16 presents the means for percentage of total possible firing time by subjects. These values are more stable than the

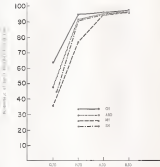


Figure 5. Percentage of total possible firing rate of neurons by condition for four subjects.

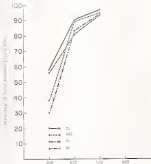


Figure 18. Percentage of total positive firing time of neurons by condition for four subjects.

Table 18. Means of percentages of total possible firing time for conditions for five subjects.

Subjects	0.20	0.25	0.30	0.35
1	66.95	63.67	66.35	67.46
2	45.35	43.54	51.65	58.81
3	35.75	61.75	65.44	58.75
4	57.50	64.78	58.11	55.34
5	13.54	58.54	58.35	—
Mean	41.82	54.28	58.02	—

conclusion that the amplitude and in fact that there is very little subject variation. In any event, the noise variability present does not affect the major findings of this study.

Order of Firing

The relative order of muscle firing was investigated to determine if an order effect among muscle firing could be observed. Measurements of onset of muscle firing were made relative to the first muscle that fired for each trial. This muscle was arbitrarily assigned a zero and thereafter time measurements were made on every other muscle from that point to the point by which the muscle began to fire. In Table II are presented the onset of the sequence of onset of firing time of the muscles being studied. Also listed is the number (N) of observations that determined the onset. It will be noticed that there is a difference. There is for all conditions, except sustained jaw opening, 80%; for sustained jaw opening, 6-26 as one subject did not complete this condition. Selection of these values reflects the fact that in some instances the muscles did not fire out of sequence, no measurement was taken. Absence of firing occurred most frequently in the masseter jaw opening and primarily in the anterior belly of the digastricus and the stylohyoid muscle.

The onset of onset of muscle firing seen in Table II gives some indication of delay in firing time for various muscles. It is seen in sustained jaw opening that the sternohyoid muscle fired last [on the average] by about 400 milliseconds while the

Table 11. Means of the measures of onset of firing in milliseconds of neurons by condition

Neuron	0.20	0.30	0.40	0.50
GB	138.3 0-27	62.3 0-30	123.3 0-30	261.4 0-65
AB	138.6 0-17	118.4 0-30	150.3 0-30	194.7 0-29
BB	223.3 0-17	128.4 0-30	178.0 0-30	73.4 0-25
DB	204.7 0-11	223.3 0-34	186.3 0-30	190.6 0-28

Other muscle firing levels are recorded since, in addition, you observe there is a difference of only 11 milliseconds between the first muscle to fire, the gastrocnemius, and the last, the anterior belly of digastricus. In addition and consistent you depressions the mean show small area disrupted patterns. Comparison of the EMG readings revealed that even from trial to trial of the same experimental condition there was considerable variability in the order of firing as well as in the mean time of firing.

Table 11 presents the rank order of firing when mean. Some inconsistency is noted, but it appears that the gastrocnemius usually fires first and the sternohyoid last. However, each motor unit has the slightest variation reveals that every muscle varied from being the first to last to being the last to fire. The above statements are highlighted by the data displayed in Table 11. The range of mean of firing time is millisecond is presented for the muscles by conditions. The wider large ranges shown indicate considerable variability in mean of firing time from trial to trial, condition to condition, and muscle to muscle. Therefore, it must be concluded that there was no systematic relative order of onset of muscle firing.

Duration of Firing

Duration of muscle firing was a measure associated with respect to the first muscle that stopped firing during any given trial. This muscle was assigned a zero and absolute time measurements were taken from this point to the cessation of EMG activity.

Table 11. Rank order of mean of flying time of wasps by conditions

Wasps	1000	1500	2000	2500	Rank
W1	1	1	1	2	1
W2	2	4	2	3	3
W3	3	2	3	1	2
W4	4	3	4	4	4

Table 13 Range of mean of flying time of median in efficiency by condition

Member	SLP	SLP	SLP	SLP
CG	SLP 0-318	0-375	0-502	0-375
AB	SLP 0-500	0-344	0-448	0-400
DE	SLP 0-755	0-300	0-500	0-344
SE	SLP 0-1344	0-400	0-600	0-600

for all other muscles

In with the stimulus obtained for most, the data in relation to firing time contain many uncertainties. The variation in $\bar{t}_f$ (as seen in Table 14) is the same as that related to onset, i.e., no RAPs were observed during some trials.

The mean of the stimulus of cessation of firing time was large for one-quarter jaw opening ranging from 1000 to 4500 milliseconds. This finding indicates that after a particular muscle fired only for a very short period. This relationship is not as readily observable for the other three experimental conditions except for the mylohyoid muscle in one-half jaw opening. Their means for maximal and minimal jaw depression are (as all instances except one) less than 300 milliseconds, indicating rather abrupt cessation of firing for all muscles.

Table 15 presents a rank ordering of cessation of firing based on Table 14. It may be seen that the mylohyoid muscle is usually the last muscle to cease firing and the mylohyoid usually first. However, there is variation in the order of firing cessation for the parotid and sublingual glands of significance. The observed variation is amplified by noting the maximum of the range of cessation of firing time for the muscles by substituting in Table 14. It is seen that every muscle in every experimental condition in the first to stop firing for at least one trial, the values range (up to 7000 milliseconds) further along in the variation. In summary, the data for cessation of firing time

Table 15: Means of the measures of *diversity of living* in millions of species by condition.

Runes	Q20	Q30	Q50	Q70
Q1	1205.3 N=13	762.0 N=10	426.0 N=10	774.1 N=14
Q2	2071.3 N=17	691.3 N=10	313.3 N=10	349.0 N=14
Q3	1721.4 N=17	136.0 N=10	134.4 N=10	337.5 N=14
Q4	4330.1 N=11	1303.3 N=14	342.3 N=10	371.1 N=14

Table 13 Rank order of necessity of firing rules motivated by stability.

Number	Q10	Q20	Q30	Q40	Mean
Q8	3	3	4	3	3.3
A33	2	2	2	2	2.0
Q6	3	1	1	1	1.5
Q9	4	4	3	4	4.0

Table 3: Range of observed β firing rate in neurons in rillaments by condition.

Neuron	Q0	Q1	Q2	Q3
28	0-100 0-1000	0-1000	0-144	0-500
307	0-100 0-1000	0-1000	0-100	0-600
313	0-100 0-1000	0-100	0-144	0-600
319	0-100 0-1000	0-1000	0-144	0-500

indicates that there is no systematic ordering of cessation of firing for the neurons.

DISCUSSION

A major finding of this investigation is that the gonion, zygion, anterior belly of the digastricus, mylohyoid, and anterior belly of the masseter are active during jaw depression. The earlier results consistently demonstrated that these muscles in function, at least, in the first half of the depression that were inactive later. This finding is in contradiction to statements by Lord (1912), Lord and Sumner (1917), and Lord (1920), that these muscles do not play a role in jaw depression. It is confirmation, however, of Meyer's (1936) observation concerning function of the digastricus. While all subjects did not register EMG in all muscles during the initial portion of one-quarter jaw opening, a general trend of increasing amplitude was noted. It is probable that the action or omission of a particular muscle in this case related to the limited extent of the quarter-jaw depression condition, variation in subject size, cross of origin, electrode placement, or some unknown factor. It is also possible that, for minimal jaw opening, relaxation of the jaw elements, except with gravitational pull, is sufficient to depress the jaw with little contribution from mylohyoid musculature. The amplitude of EMG in one-quarter jaw opening is, on the average, half the amplitude of one-half jaw depression. This would further indicate the action of a muscle in one-quarter jaw opening is

Influenced by a variety of factors. In addition to the fact that all muscles do not act in one-quarter jaw opening, the results that the first subjects were variability from subject to subject. In any case, all muscles fired during the entire closed experimental condition. This would denote the necessity of their action to effect jaw depression.

A second major finding revealed a systematic relationship between degree of jaw opening and amplitude of EMG, i.e., as the degree of jaw opening increased, the amplitude of EMG increased as well. This finding agrees with the observation of MacDougall and Johnson (1954) that the upper and individual muscles show activity beyond the working potential as loads for normal and resisted jaw opening. This increase in EMG related to other contractions of the mandible is apparently due to recruitment of potentials as the force of the contraction increases (Hammel, 1944). In fact, this explanation agrees with that of Huxley and Gosselink (1944) who showed that action potentials tend to increase in amplitude with excitation and fatigue during isometric contractions of normal muscles.

During each experimental condition the amplitude of EMG was similar for all muscles indicating that they act as a group to effect jaw depression. This similarity was apparent also when the right and left muscle pairs were compared. If the muscle pairs did not function in tandem there would be an unequal pull on the mandible and a lateral deviation of the jaw on opening as is noted when only one of the masticatory parasyphs is functioning. If the muscles

Investigation did not definitively, it could be expected that a hypodiploid nucleus would divide. This was not the case. The expected action of these muscles would seem to contribute to the expenditure and refinement of movement as Rogers (1960) has demonstrated.

The slight weakness of the mesothorax in which the mesothoracic MAF than the other muscles might suggest that the infradiploid muscles do not divide the hybrid form as readily as has been suggested in the past. While the relative power of the muscles cannot be assessed from this investigation, the lower amplitude of the mesothoracic might indicate a possible differentiation of function between the upper and infradiploid groups. It is also possible that the mesothoracic muscle is not as active as the other infradiploid muscles.

Clearly paralleling the findings and implications of amplitude of MAF are those relative to function. Duration of muscle firing varies little from subject to subject in normal and restricted jaw opening indicating a nearly automatic firing is necessary to maintain these various positions. It is probable also that when additional muscular tension is maintained in maximal opening, antagonistic muscles would tend to close the mouth. The functional nature of mastication, and to a less extent mastication (jaw depression), with accompanying individual differences among subjects. The variability of firing time duration perhaps is a correlate of Shale's finding, cited in Kowojan (1967), that greater efficiency

and specificity of a response produces a gradual learning in the sensory function of perception. It also seems reasonable that a reduced mass function time might indicate a reduced effect of the muscle in a specific way, e.g., demonstrating that its joint activities in anticipate the movement for the individual.

No differential in duration of firing of the muscles was found which tends to demonstrate, as with amplitude, that they act in a coordinated manner with respect to jaw depression. If this were not the case, the relative influence of one muscle, or another, would be somewhat difficult to specify. The lack of any difference in duration of firing between the right and left sides of the muscles investigated indicates again, as with amplitude, that these muscles function to maintain the mouth in a mid-line position for simple jaw depression. This relationship would most probably be altered in lateral movements of the jaw.

A specific sequencing of initiation and cessation of muscle firing was not observed although any such trends may have been obscured by subject and explanation variability. The only trend noted was that the submandibular muscle began last and ended last. This would indicate an efferent function of the submandibular and possibly the infrahyoid as group. If the suprahyoid is last in contracting, their lateral pull on the hyoid may act as the counterbalance stimulus for restoration of the infrahyoid. Conversely, if they stop first, the infrahyoid may continue to contract for a short time to restore the hyoid bone to its original resting position.

It might be argued that when jaw springing ceases, and the jaw elevators are sustained, the activity of the masseter lateralis-geni would suddenly stop. While this was true in some cases, the muscles did not revert immediately to a resting state. Activity, though diminished, continued even when the jaw was closed. (This was especially evident in maximal opening.) One explanation of this phenomenon would be that since the muscles were under tension for a period of time, immediate relaxation was not possible. The effects of fatigue are complex and have numerous components that cannot be explained from the results of this study.

In summary, this investigation has demonstrated that the muscles studied are active in jaw depression, exhibit greater amplitude, and firing time as degree of jaw opening increases, but show no demonstrable differential action.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this investigation was to determine the presence or absence of specific action of the posthypod, anterior belly of the digastricus, epistaphylid, and sternohyal muscles in unpaired manequins, newborn, mature, and in the postnatal condition (see opening). To study these relationships, muscle action potentials were obtained electrophysiologically using needle electrodes. Five normal adult males served as subjects, performing each experimental condition in the following order: un-paired, newborn, mature, and postnatal (see opening). Each of the experimental conditions was repeated three times in immediate succession.

Measurements of amplitude and muscle firing rate were obtained from the electrophysiologic tracings. Amplitude was defined as the distance of the potential from the negative to the positive peak, the percentage of total possible firing rate was defined as a ratio between the length of firing of a specific muscle divided by the duration of the total firing time for the specific set. Amplitude measures were obtained by measuring the millimeter grid tracing graph paper on the screen, measuring the extent of amplitude during each 50 millisecond period and then averaging these values over a 500 millisecond period. Rate or duration were obtained by

measuring the onset firing time of each muscle and making the appropriate calculations.

The major conclusion provided by this research is that the muscles studied are active in jaw depression. Moreover, the following specific conclusions were justified:

First, the muscle action potentials of the muscles under study increase in amplitude as the degree of jaw depression increases. In addition, duration of firing increases systematically also.

Finally, there does not appear to be a differential action among any of the muscles studied with respect to the experimental conditions investigated.

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This dissertation was prepared under the direction of the
[chairman of the candidate's supervisory committee and has been
approved by all members of that committee. It was submitted to
the Dean of the College of Arts and Sciences and to the Graduate
Council, and was approved as partial fulfillment of the require-
ments for the degree of Doctor of Philosophy.

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